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CORE-LOC BREAKWATER ARMOUR RESEARCH

Breakwater Survey at Port St Francis

FINAL REPORT

by

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and
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Council for Scientific and Industrial Research (CSIR)

November 1998

for

United States Army
EUROPEAN RESEARCH OFFICE OF THE U.S. ARMY
London, England

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An agreement was signed between the Council for Scientific and Industrial Research (CSIR) and the U.S Government through its European Research Office of the U.S Army, for the CSIR to undertake monitoring surveys of the first core-loc breakwater constructed in Port St Francis, South Africa. Following the base-line survey of the Port St Francis breakwater, undertaken in October 1997, a follow-up survey was carried out on 26 May 1998. Both surveys consisted of an aerial photographic series taken from a helicopter using DGPS for positioning, a visual inspection, and a diving inspection, and a "crane and ball" profiling survey. Survey results and analysis of the baseline and follow-up surveys are summarised in this report.

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Ports and Coastal Structures Programme
Core-loc Breakwater Armour Research

Breakwater Survey at Port St Francis

SCOPE

The first prototype application of a Core-loc armoured breakwater was constructed for the small craft harbour at Port St Francis, South Africa in 1996/97. The breakwater at Port St Francis is privately owned and was financed by the developers of the marina and adjacent housing development. Initial baseline and subsequent breakwater surveys are essential to the assessment of concrete armour performance. From the baseline survey, Core-loc damage progress and performance can be assessed in subsequent years. Yearly breakwater surveys can be used to develop a track record for Core-loc as an alternative cost effective breakwater armour unit.

An agreement was signed between the Council for Scientific and Industrial Research (CSIR) and the U.S Government through its European Research Office of the U.S Army, for the CSIR to undertake monitoring surveys of the Port St Francis breakwater. The agreement also included two dimensional model tests to establish the stability of Core-loc breakwaters under typical South African wave conditions. This report is the final report of the results of the monitoring undertaken for the Port St Francis breakwater by the CSIR, as required by the contract (Contract No.N68171-97-M-5B23). The report covers the results of the baseline survey undertaken on the 10 October 1997 and the follow-up survey undertaken on the 26 May 1998.

The CSIR survey team included D Phelp, R Vonk, S Heather-Clark and K Blake, and the report was written by D Phelp and S Heather-Clark. G Turk and J Melby of the Coastal Engineering Research Centre (CERC), US Army Corps of Engineers also assisted with the baseline survey.

DAVE PHELP | *Stellenbosch*
Ports & Coastal Structures | *November 1998*

SUMMARY

An agreement was signed between the Council for Scientific and Industrial Research (CSIR) and the U.S Government through its European Research Office of the U.S Army, for the CSIR to undertake monitoring surveys of the first core-loc breakwater constructed in Port St Francis, South Africa. Three extreme (near design) storms were experienced during early stages of the construction phase of the breakwater. These storms contributed to the displacement of many Core-loc units out of their allocated positions. This gave rise to poor interlocking in some areas and resulted in a non-uniform slope, especially on the bend of the outer breakwater. Additional Core-loc units were needed to fill gaps in the armouring, sometimes resulting in a semi-double layer. Up to 20 loose or damaged units were also removed from the toe and re-used on the breakwater.

The near design storms, together with the problems (under-layer size and placement problems) experienced during the construction phase of the breakwater, contributed to the majority of damage (displaced and broken Core-loc units) identified during the baseline survey in October 1997. In total, 35 units were damaged, 30 on the main breakwater and 5 on the revetment. All of this damage occurred during the construction phase before completion of the mass-capping and crown wall.

Initial placement problems were largely overcome during the construction of the revetment as this was constructed after the breakwater. This lead to more stable armour protection in this area, with good interlocking and a uniform slope.

The follow-up aerial photographic survey done in May 1998, showed very little further damage to the breakwater and no further damage to the revetment, despite the occurrence of another near-design storm after the baseline survey. Only 4 Core-loc units were recorded as new damage resulting from extreme storm conditions between October 1997 and May 1998. Two of the previously damaged units, which were already weakened, were also found to have broken further. This low damage figure represents the true performance of the new Core-loc breakwater, excluding the problems experienced during construction.

Keywords:

Core-loc
Port St Francis
Breakwater
Photographic survey

1. INTRODUCTION

The first prototype application of a Core-Loc armoured breakwater was constructed for the Port of St Francis, South Africa in 1996/97. The initial baseline breakwater surveys were carried out jointly by CSIR and CERC in October 1997. These surveys consisted of a aerial photographic survey taken from a helicopter using pre-determined DGPS for positioning, a visual inspection, a crane and ball section survey and a diving inspection. In order to monitor the early performance of the completed breakwater, it was decided to carry out follow-up surveys after 6 months. These surveys were carried out on 26 May 1998, excluding a crane and ball profiling survey.

On completion of both surveys, a presentation of the results were made at the International Conference on Coastal Engineering (ICCE) held in Copenhagen, Denmark in June 1998. The results of the surveys were discussed between CSIR and CERC both before and during the ICCE conference.

2. SURVEY PROCEDURES

The surveys included an aerial photographic survey, a “crane and ball” survey, a visual inspection of the breakwater and revetment, and a diving inspection. The baseline surveys were undertaken on the 10 October 1997 and the follow-up surveys on the 26 May 1998. These were used to provide as-built data and document the breakage type, count and location of damaged Core-loc armour units.

2.1 Visual inspection

The first visual inspection was carried out by Melby and Turk from CERC, to record the location and type of Core-loc breakage. This was done by climbing over the Core-loc slope during low spring tide and relating the positions to the ball survey lines which were marked on the splash wall. The second visual inspection was carried out by Phelp and Heather-Clark from the CSIR, to record any further damage to the Core-loc units. The recorded damage was later correlated with that seen in the aerial photos (Table 1 and Table 2).

2.2 Photographic survey

2.2.1 *Navigation and position fixing*

A "Robinson 44" 4-seater helicopter, was used to elevate the camera to a position perpendicular to the slope of the Core-loc armouring. Pre-determined coordinates were chosen to give good coverage, with photo stations spaced at 26m centres on the straight sections of breakwater and 13m centres over the curved sections. Figure 1 shows the layout of the survey stations on both the outer breakwater and inner revetment.

Navigation of the helicopter was carried out with the aid of a "Landstar" Differential Global Positioning System (DGPS). DGPS is a satellite-based positioning system which achieves high accuracies by utilizing real time transmitted corrections from a reference station, placed at a known location. This then provides dynamic positioning of the survey camera, to an accuracy of plus/minus 0,5 m. The altitude of the helicopter was kept at 65 m above the breakwater slope.

2.2.2 *Camera specification and photography*

The photographs were taken with a Nikon 35 mm camera with a 50 mm lens and using 200 ISO colour film. The photo stations were marked on the breakwater and the revetment and numbered 1 to 12 and 13 to 21 respectively (Figure 1) and were positioned at the centre of each photograph. This allowed for each station to include approximately 50 Core-loc units per photograph. By careful observation of the approaching waves, the photographs were taken at maximum wave draw-down to ensure that the maximum area of Core-locs (approximately 90%) were exposed, including those units below the low tide level.

2.3 "Crane and Ball" section survey

A mobile crane with an 18 m reach was used for the "crane and ball survey". The radius of the ball used for the survey was 1 metre. The survey was carried out by positioning that crane at each station (Figure 1) with the boom perpendicular to the breakwater. The profile of the Core-loc armour units was then measured by suspending the ball from the boom by a calibrated staff. Starting from the splash wall the levels were measured at 3 metre intervals along the boom.

A DGPS satellite system was mounted on the top of the boom to fix the positions at which the levels were taken. The levels of the ball were recorded by dumpy level from the capping and related back to the top of the splash wall at a level of +6,5 m MSL. At each position the ball was lowered until it touched the Core-locs. The levels were reduced to zero datum at the top of the splash wall, Chart Datum (CD) is also shown on the plots (Figures 4 to 10).

2.4 Diving inspection

A diving inspection was undertaken by a diver in the water and an assistant on the breakwater to record the position and state of the underwater part of the breakwater. The diver swam along the toe of the main breakwater from the inner roundhead, along the outer slope to the root. The inner revetment was not included in the diving survey, as the toe was mostly exposed during low spring tide, and could be monitored by the aerial photographic survey. Poor visibility reduced the effectiveness of the diving survey to counting broken units and recording those units which had moved away from the breakwater toe.

3. SEA CONDITIONS

3.1 Sea conditions during surveys

Both sets of surveys were undertaken during low spring tide where sea conditions were mild with a slight swell. During the baseline survey the sky was overcast, there was little wind and the underwater visibility was poor. During the follow-up survey the sky was clear, there was little to no wind and underwater visibility was good.

3.2 Sea conditions during construction

Although the relatively shallow bathymetry off the harbour causes depth limited wave conditions, three near design storms were experienced during construction (i.e. when the breakwater was uncapped and at +3,5m MSL working level). This resulted in overtopping and breaching of the uncompleted breakwater. As a result several Core-loc units were displaced from the slope and required replacement and re-packing. One design storm was also experienced after completion of the construction of the breakwater and the first baseline survey in October 1997. This caused little further damage to the well compacted (shaken down) slope.

4. SURVEY RESULTS AND ANALYSIS

4.1 Construction problems

To ensure sound breakwater concrete armour protection, it is imperative that good interlocking is achieved, especially when placing a single layer armouring system such as with Core-loc. This is done by accurately placing the individual units on a prescribed grid. This grid must be correct, right from the toe units which then form the foundation for the upper rows to lock onto. On the main breakwater it was apparent from diving surveys that some Core-loc were incorrectly placed seawards of the design toe, besides the units that were displaced during the storm events.

The extreme storms experienced during early stages of construction also contributed to the displacement of many Core-loc units out of their allocated positions, both up and down the armour slope. This gave rise to poor interlocking in some areas and resulted in a non-uniform slope, especially on the bend of the breakwater. Additional Core-loc units were needed to fill gaps in the armouring, sometimes resulting in a semi-double layer. Up to 20 loose or damaged units were also removed from the toe and re-used on the breakwater.

During the construction phase the low crest working level (+3,5 m MSL) left the breakwater unprotected against wave overtopping, resulting in the displacement of a number of crest units during the near design storms that were experienced before construction of the mass-capping. During one of the storms, overtopping caused a breach of the core material and the displacement of Core-loc units into the harbour. Most of these units were recovered and re-packed on the front slope. Some grading problems with the under-layer rock also caused an irregular profile. Figure 2 shows the breakwater, revetment and marina still under construction.

Initial placement problems were largely overcome during the construction of the revetment as this was constructed after the breakwater. This lead to a better constructed armour protection in this area, with good interlocking and a uniform slope (Figure 3). The revetment was also partially protected by the main breakwater and the working level during construction was higher, so that there were no serious overtopping problems.

4.2 Visual survey and diving inspection

After storm damage, loose Core-locs were found in front of the rock toe of the breakwater during the diving inspection. These units were most likely displaced due to poor interlocking resulting from poor placement during construction. The interlocking also

appear to be less effective where the slope of the toe is flatter. The loose Core-locs identified during the diving inspection were recovered and re-used on the breakwater.

The diving inspections also confirmed the buildup of sand along the toe which had completely covered the rock berm and the first row of Core-loc. This buildup occurred within the first year after completion of the breakwater. Apart from adding to the overall stability of the structures, it also results in reduced wave heights reaching the armouring.

The toe of the revetment showed no displacement damaged compared to the breakwater. This was confirmed by the aerial photographs which revealed that the manner in which the first row of Core-locs had been placed, i.e. behind the toe berm in a "cannon" orientation with the middle fluke (nose-tip) pointing outwards, provided the most stable foundation on which to build the rest of the slope. Areas where the armour slope had become flattened (e.g. storm damage around the bend in the main breakwater) resulted in looser packing and poorer interlocking of the Core-loc. This did not occur on the revetment where each row of Core-loc was well anchored with the row above, resulting in a strong uniform slope.

4.3 Crane and ball section surveys

As a result of the storm damage during construction, the as-built crane and ball section surveys recorded the re-packed breakwater and not the ideal slope as should have been placed according to the original design (Figures 4 to 10). Furthermore, the survey gave a profile generally 1 metre higher than the design profile. The latter was closer to the levelling survey taken by holding a staff on the centroid of each Core-loc, as carried out by A.R. Wijnberg Inc. Figures 8 and 9 show the "S" damage profile at stations 16 to 23 where most of the storm damage and breaching took place during construction.

4.4 Photographic survey

Damaged and displaced Core-loc units that were identified during the visual and aerial photographic baseline surveys are included in Table 1. Photographs showing this damage are included in Figures 11 to 31. From the analysis of the baseline photographs, almost double the damage was recorded than that previously recorded in the visual survey undertaken by Turk and Melby from CERC. This is possibly because it was difficult to reach the lower units due to wave action, whereas the helicopter could hover while waiting for wave draw-down, before taking the photograph. The broken Core-loc units are indicated on the photographic records (Figures 11 to 31).

Although there was unusual storm damage during construction, the normal "shake down" or "settling in" damage (found to be more than double the average annual damage - Phelp, 1994) took place before the baseline survey. Additional Core-loc units were also placed on the upper slope of the breakwater after completion of the mass capping to replace displaced units and to complete the structure . Without a complete re-pack of the entire slope, it proved difficult to fit additional units in the open spaces. Some concrete bags were placed to stabilise loose units, which proved to be successful and minor further damage to the breakwater occurred after shake down. The repairs to the bend in the breakwater have resulted in an "S" shaped cross-section similar to a dynamically stable rock berm (Figures 8 and 9).

Of the total 800 Core-locs used for the breakwater and the revetment , a total of 35 units were damaged during the construction phase of the harbour, prior to the baseline survey. The majority of the damaged units being on the main breakwater (30 on the breakwater and 5 on the revetment).

The follow-up aerial photographic survey done in May 1998, showed very little further damage to the breakwater and no further damage to the revetment, despite the occurrence of another near-design storm after the baseline survey (Figures 32 to 41). This damage is indicated in Table 2. Only 4 Core-loc units were recorded as new damage resulting from extreme storm conditions between October 1997 and May 1998. Two of the previously damaged units, which were already weakened, were found to have broken further. This low damage figure represents the true performance of the new Core-loc breakwater, excluding the problems experienced during construction.

After the baseline survey, the different types of breaks were identified for each damaged unit and totals were calculated accordingly. The percentages of the various breakage categories is indicated in the table below:

Breakage Type	**% Breakage**
H-tip breaks (one tip only)	61%
Double H-tip breaks	5%
Nose-tip breaks	13%
Middle breaks (unit broken in half)	13%
Multiple breaks (more than 2 pieces)	8%

Of the breakage that did occur, 13% were located towards the top of the breakwater slope, 47% in the middle and 40% at the bottom. Large Core-loc movements (> 3H, where H is the height of a Core-loc unit) were recorded without breakage, especially at the section that was breached during the construction phase. Breakages that were noted at the breached section may have resulted from the tumbling that occurred as a result of the erosion of the lee side of the breakwater. Several Core-locs displayed signs of impact (spalling) without breakage.

The units that experienced the H-tip and double H-tip breakages retain approximately 90% of their original weight allowing them to adequately provide the necessary protection. Furthermore, the majority of these units still appear to be well interlocked with the surrounding units. Other types of breakages recorded may also have occurred as a result of poor quality control during the making and placing of the units in the construction phase.

The revetment was built to a final height of +7 m MSL, whereas the main breakwater was built to an interim height of +3,5 m before the mass-capping was cast. The revetment was also built after the main breakwater, which meant that, besides being partially in the lee of the main breakwater, the construction crew had more experience with handling the single layer Core-loc units. The underlying rock layer also appeared to be more uniform which allowed for easier placing of the Core-loc units, correctly positioned right from the toe of the slope. The free Core-loc units at the northern end of the revetment were secured by a concrete buttress / caissons anchored to the sea-bed, which proved very successful. As a result the revetment has shown minimum shake down damage.

5. CONCLUSION

From the analysis of the survey results and observations during the construction phase of the breakwater, the following conclusion are made:

- The Core-loc breakwater armour unit, as used for the first time at Port St Francis, has proved successful, despite some difficulties during construction.
- Excluding the damage recorded during the breakwater construction, the damage recorded by a follow-up survey was 4 broken units, which is 0,5% of the total of 800 units, despite the occurrence of further design storm sea conditions.
- Minimal as-built damage was found on the revetment, and no additional damage was recorded by the follow-up survey. This was no doubt due to the good packing and interlocking achieved on this part of the protection structure.
- CERC research showing improved structural stability (over other slender units) has proved itself in the field, with less breakage under extreme conditions. This allows recovery and re-use of displaced units (> 3H displacement recorded without breakage).
- Despite the high damage during construction, almost 80% of the total number of breaks consisted of either single "H-tip" fluke breaks, "nose-tip" breaks or double "H-tip" breaks, which still leaves 90% of the original unit weight allowing the units to remain well interlocked and functional. This will reduce the maintenance required during the lifetime of the structure.
- Good interlocking (as achieved on the revetment) is especially important for single layer armour units such as Core-loc. A well placed toe and a uniform slope are essential to achieve this, as is accurate placement of the armour units on a pre-determined grid.
- The stability of the toe units is especially important for a "shallow water" breakwater, such as is the case at Port St Francis, where the waves break directly onto the toe of the structure.

6. FUTURE RESEARCH PLANS

A third photographic survey of the breakwater will be undertaken at the end of 1998, one year after the baseline survey, to monitor any further damage to the "settled in" Core-locs. Furthermore, two dimensional model tests are presently being undertaken to establish the stability of Core-loc breakwaters under typical South African wave conditions. The tests include the use of Core-loc to repair damaged dolos structures, together with a comparison of the overtopping between a double layer dolos structure and a single layer Core-loc structure.

7. LIST OF CSIR PERSONNEL INVOLVED IN PORT ST FRANCIS BREAKWATER MONITORING

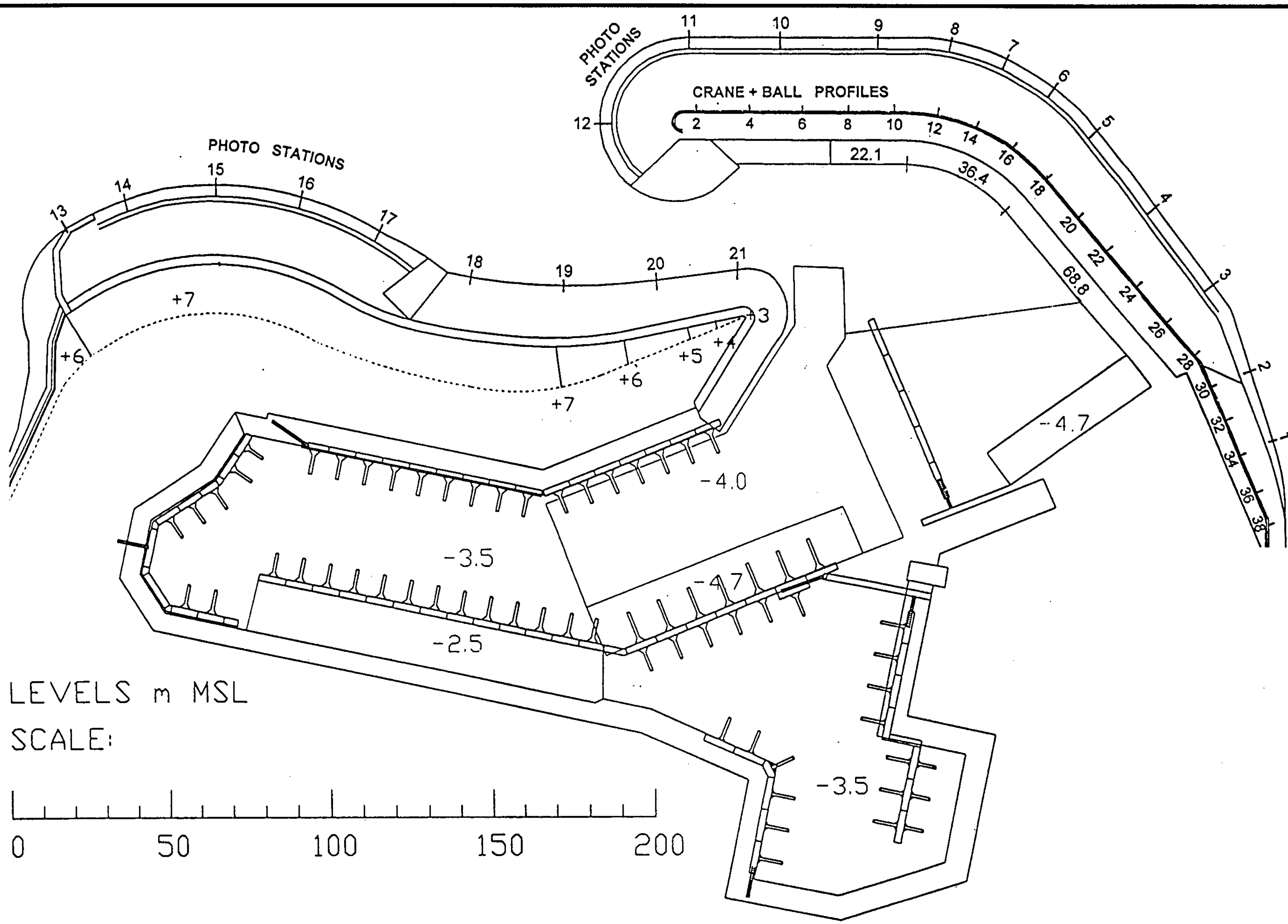
Dave Phelp
Kevan Blake
Stuart Heather-Clark

8. LIST OF PUBLICATIONS

Papers submitted to the 1998 ICCE Conference:

Title : Results of Field Monitoring of the New Core-Loc Breakwater at Port St Francis - South Africa
Authors: Dave Phelp (CSIR)
Anton Holtzausen (WPR)
Jeff Melby (CERC)

Title: The first Core-loc Breakwater
Author: Anton Holtzausen (WPR)



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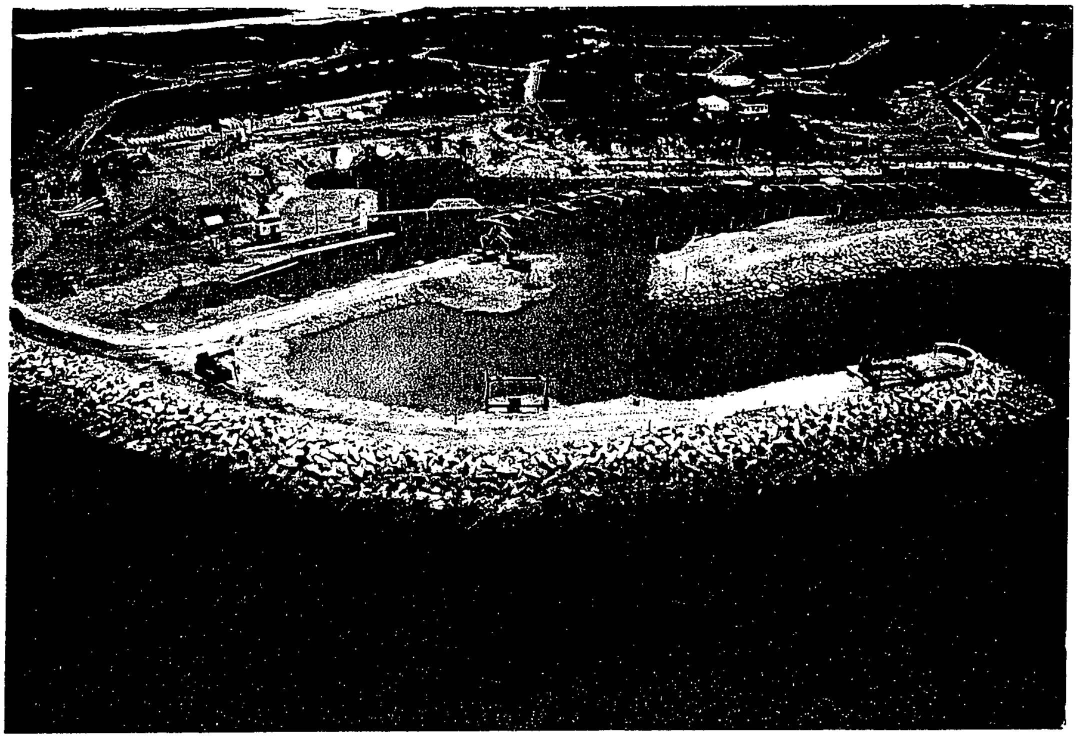
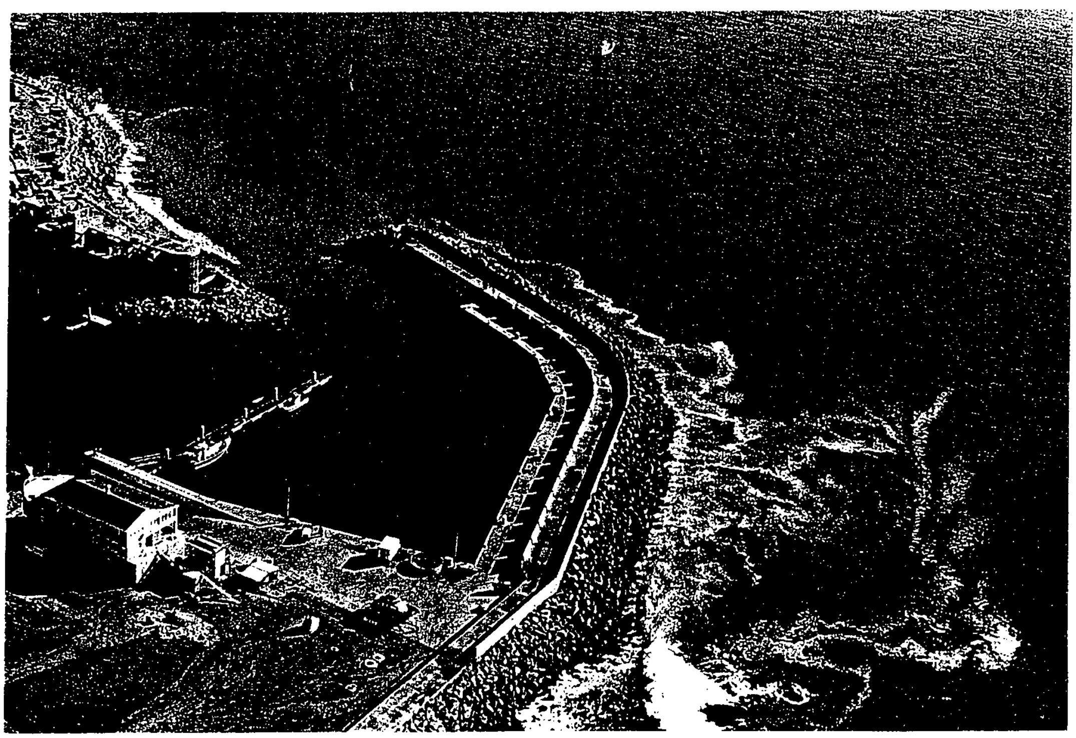
SURVEY STATIONS

FIGURE 1

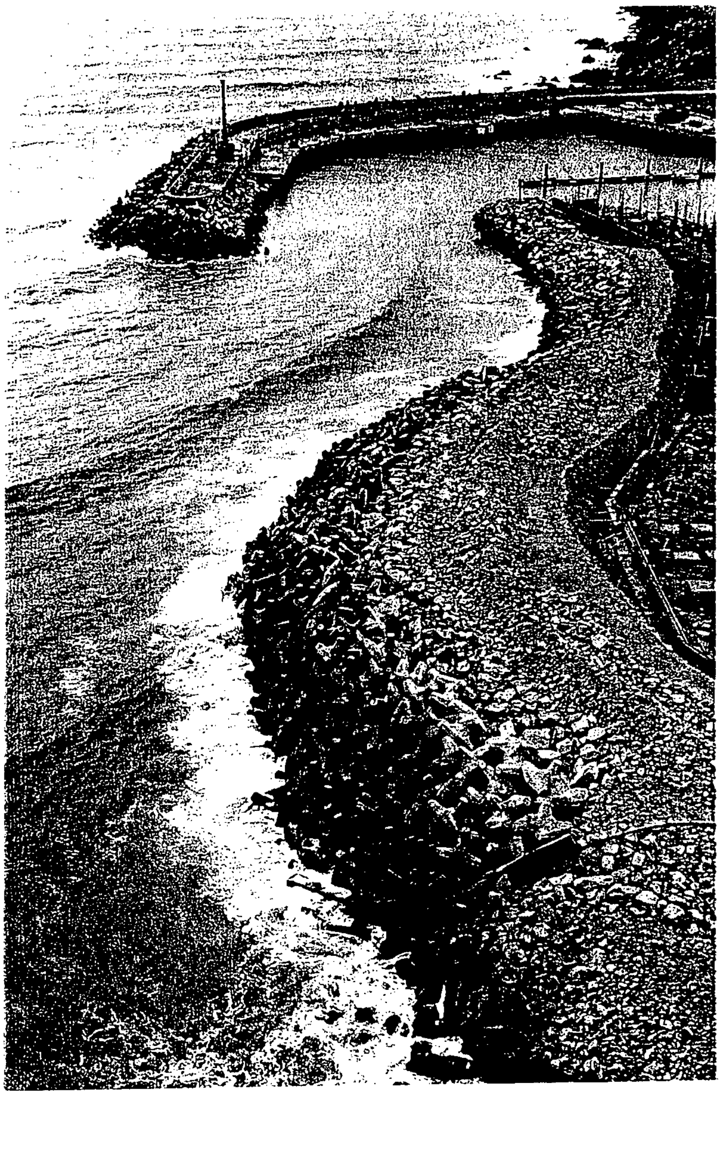


Breakwater revetment and marina under construction



View of completed breakwater and revetment

CSIR Your Technology Partner	PORT ST FRANCIS **PORT ST FRANCIS BREAKWATER SURVEY**	**FIGURE** **2**



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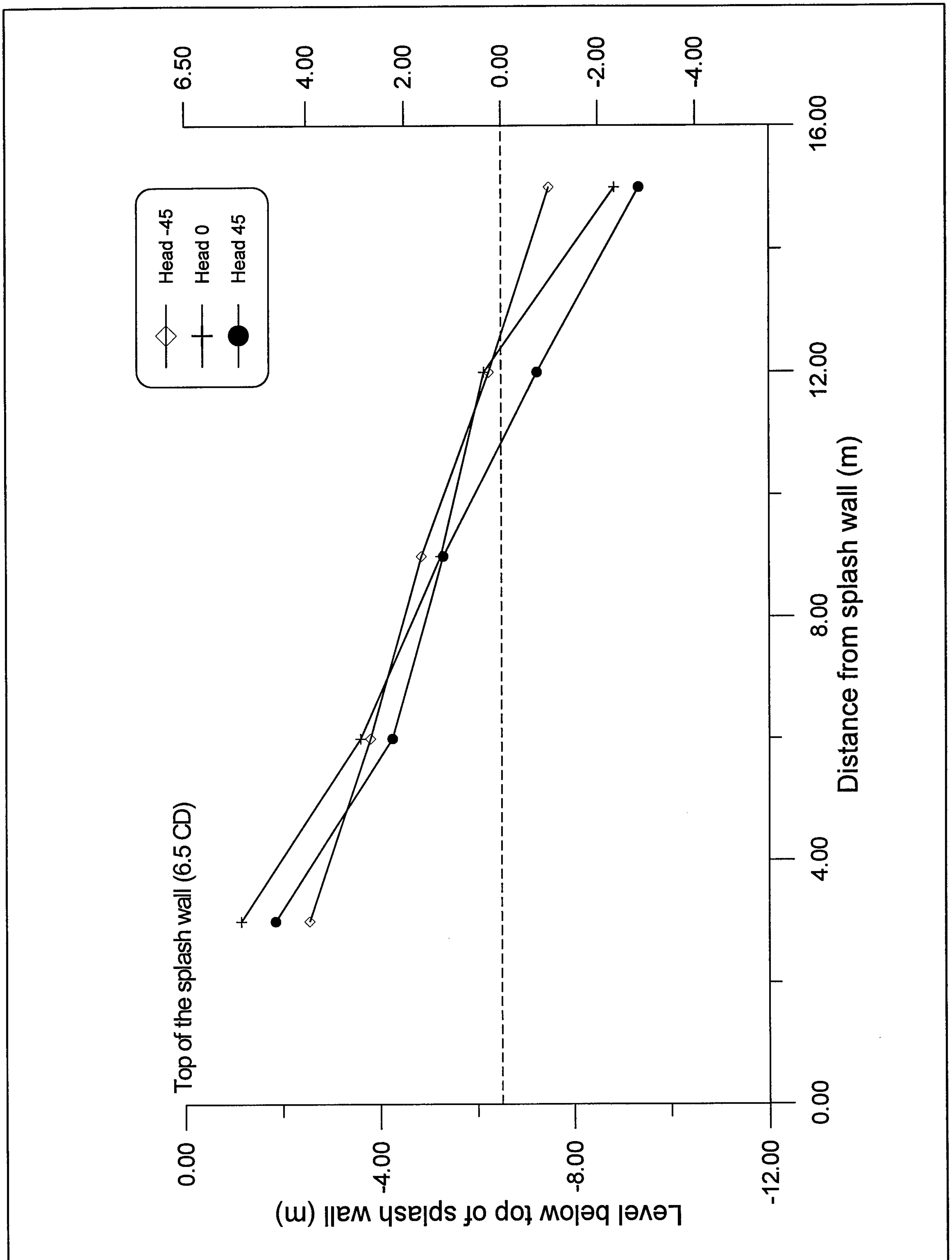
REVETMENT AND MAIN BREAKWATER

FIGURE 3



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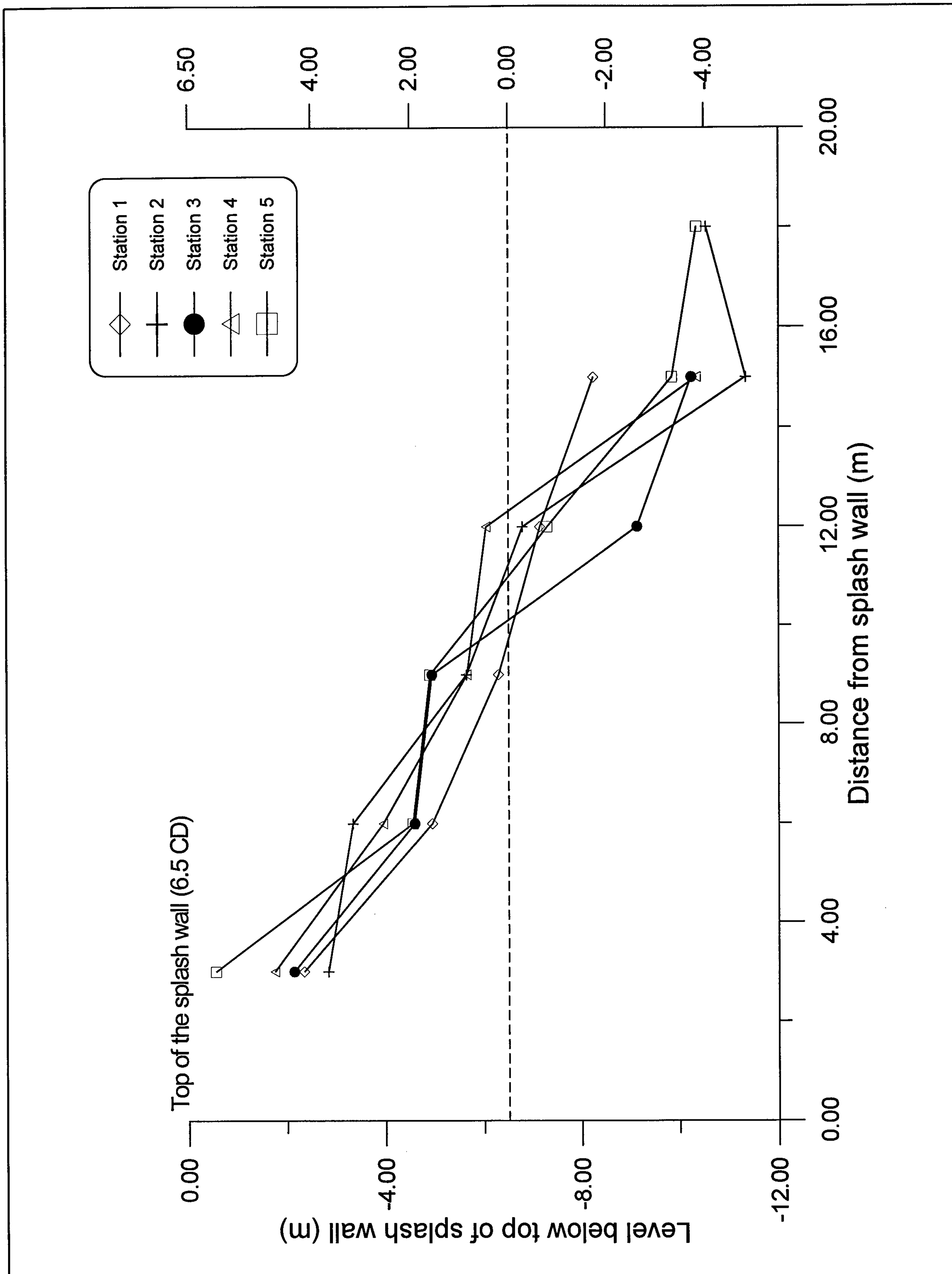
PORT ST. FRANCIS
MAIN BREAK WATER CRANE & BALL SURVEY

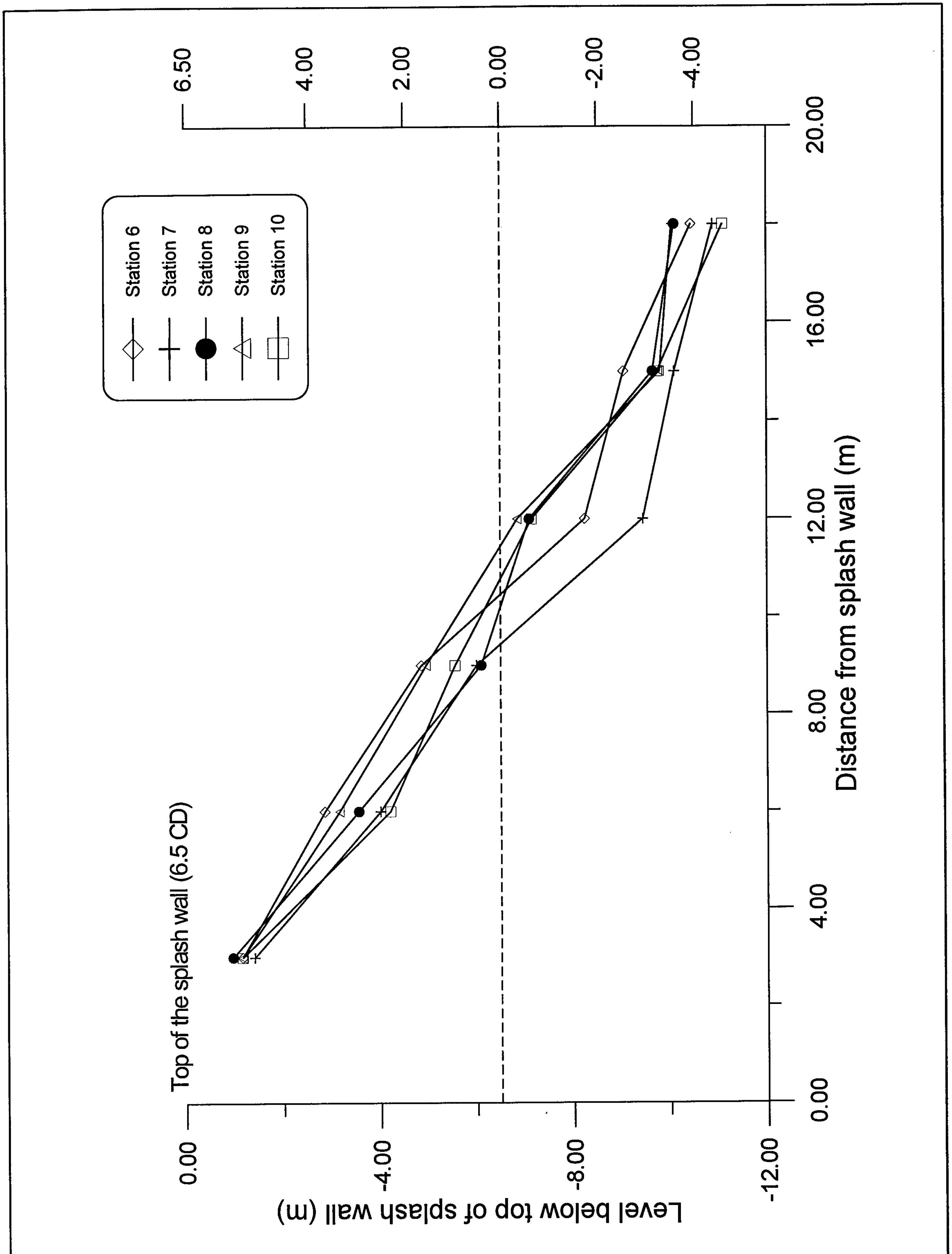
Figure 4

h45.grf



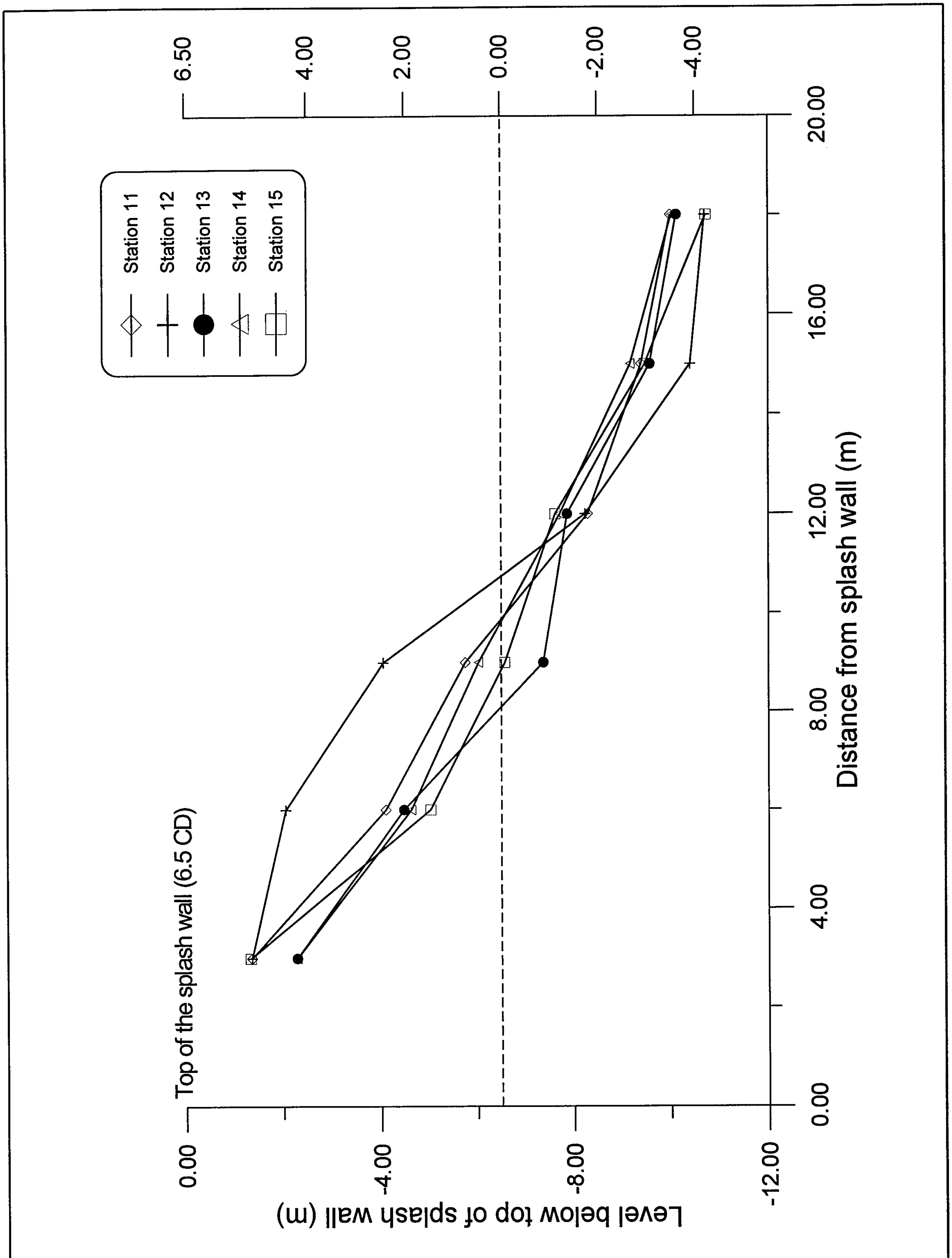
CSIR ENVIRONMENTEK	PORT ST.FRANCIS MAIN BREAKWATER CRANE & BALL SURVEY - STATIONS 1 TO 5	Figure 5

st1to5.grf



CSIR ENVIRONMENTEK	PORT ST.FRANCIS MAIN BREAKWATER CRANE & BALL SURVEY - STATIONS 6 TO 10	Figure 6

st6to10.grf

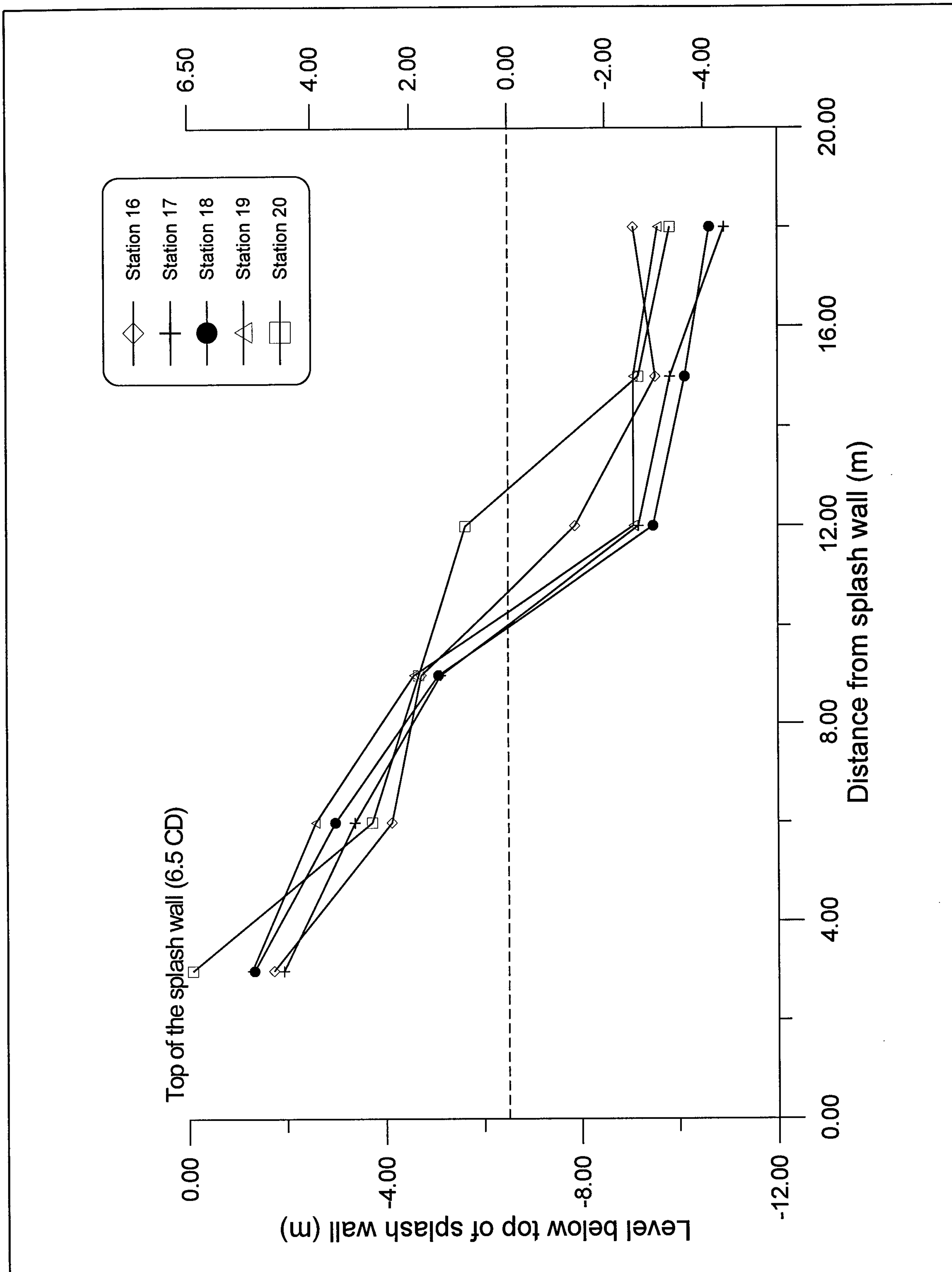


CSIR ENVIRONMENTEK

PORT ST. FRANCIS MAIN BREAKWATER
CRANE & BALL SURVERY - STATIONS 11 TO 15

Figure 7

s11to15.grf



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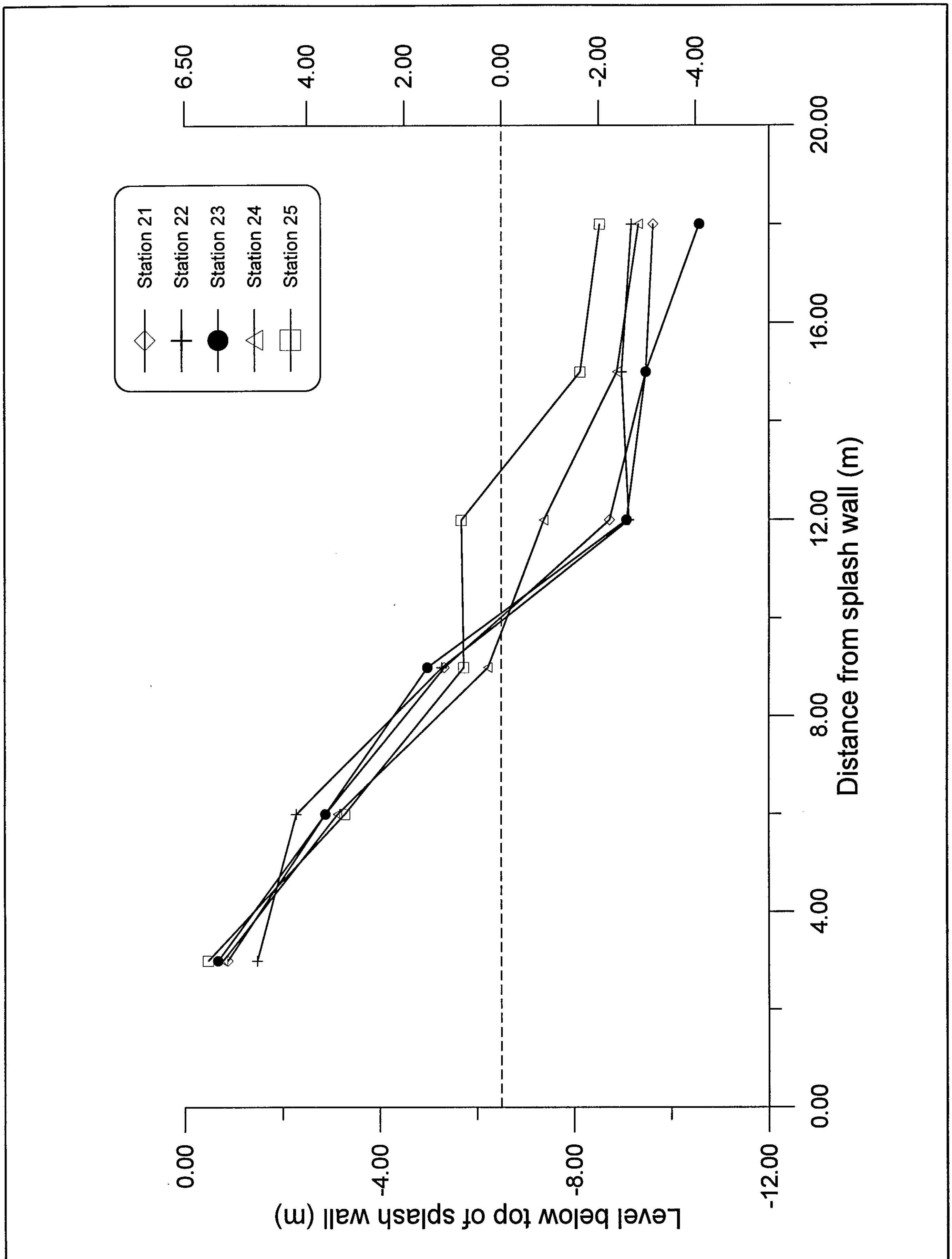
ST.FRANCIS MAIN BREAKWATER
CRANE & BALL SURVEY - STATIONS 16 TO 20

Figure 8

s16to20.grf



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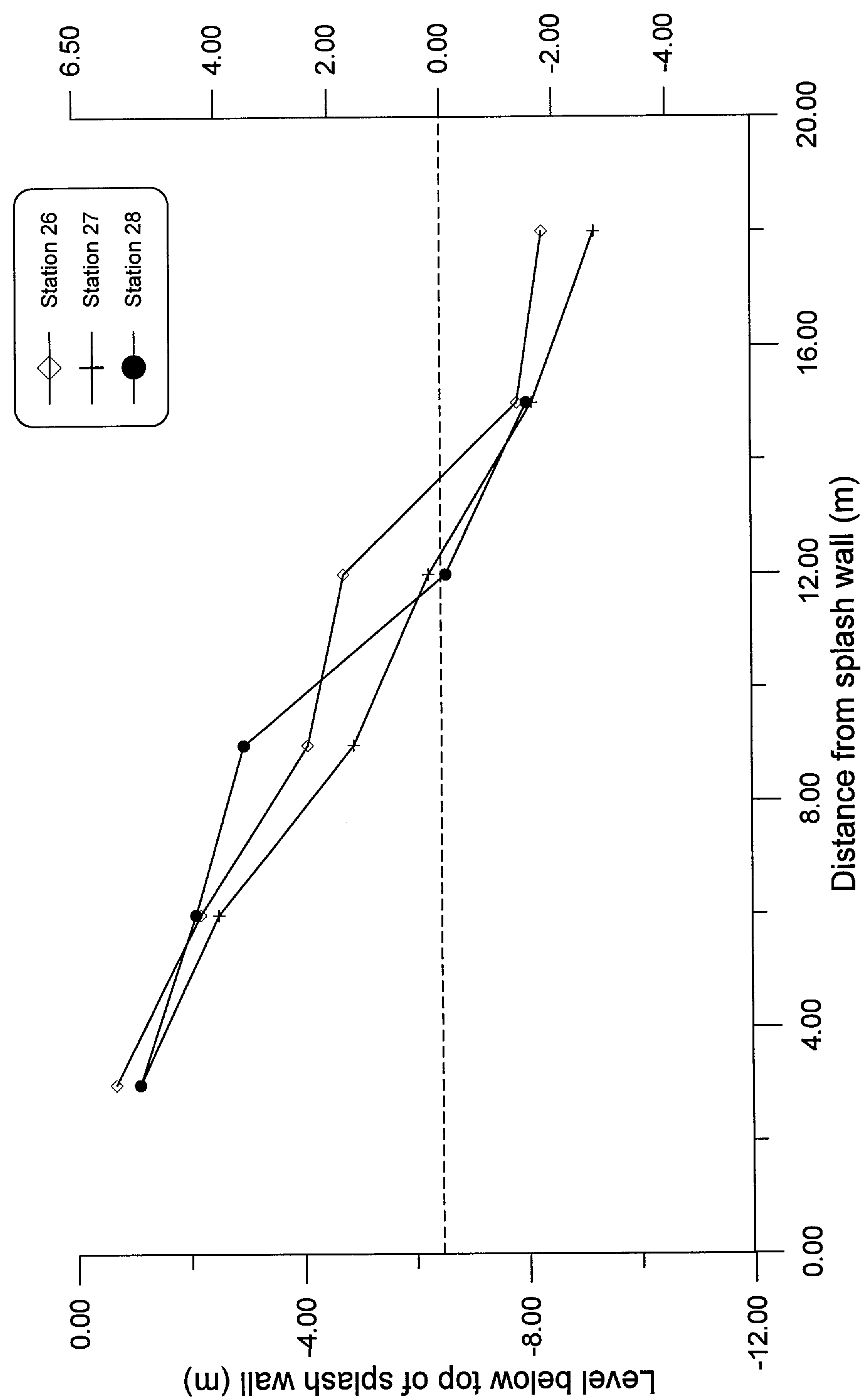
ST.FRANCIS MAIN BREAKWATER
CRANE & BALL SURVEY - STATIONS 21 TO 25

Figure 9

s21to25.grf



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ST.FRANCIS MAIN BREAKWATER
CRANE & BALL SURVEY - STATIONS 26 TO 28

Figure 10

s26to28.grf

Move (■) : 0 Broken (▲) : 0 Lost (●) : 0

N = New, P = Pieces, A = <0,5m, B = 0,5m to 1,5m, C = >1,5m

CSIR Your Technology Partner	PORT ST FRANCIS **BASELINE PHOTOGRAPHIC SURVEY OCTOBER 1997 STATION 1**	**FIGURE 11**

Move (■) : 0 Broken (▲) : 0 Lost (●) : 0

N = New, P = Pieces, A = <0,5m, B = 0,5m to 1,5m, C = >1,5m

CSIR Your Technology Partner	PORT ST FRANCIS **BASELINE PHOTOGRAPHIC SURVEY OCTOBER 1997 STATION 2**	**FIGURE 12**

Move (■) : 0 Broken (▲) : 0 Lost (●) : 0

N = New, P = Pieces, A = <0,5m, B = 0,5m to 1,5m, C = >1,5m

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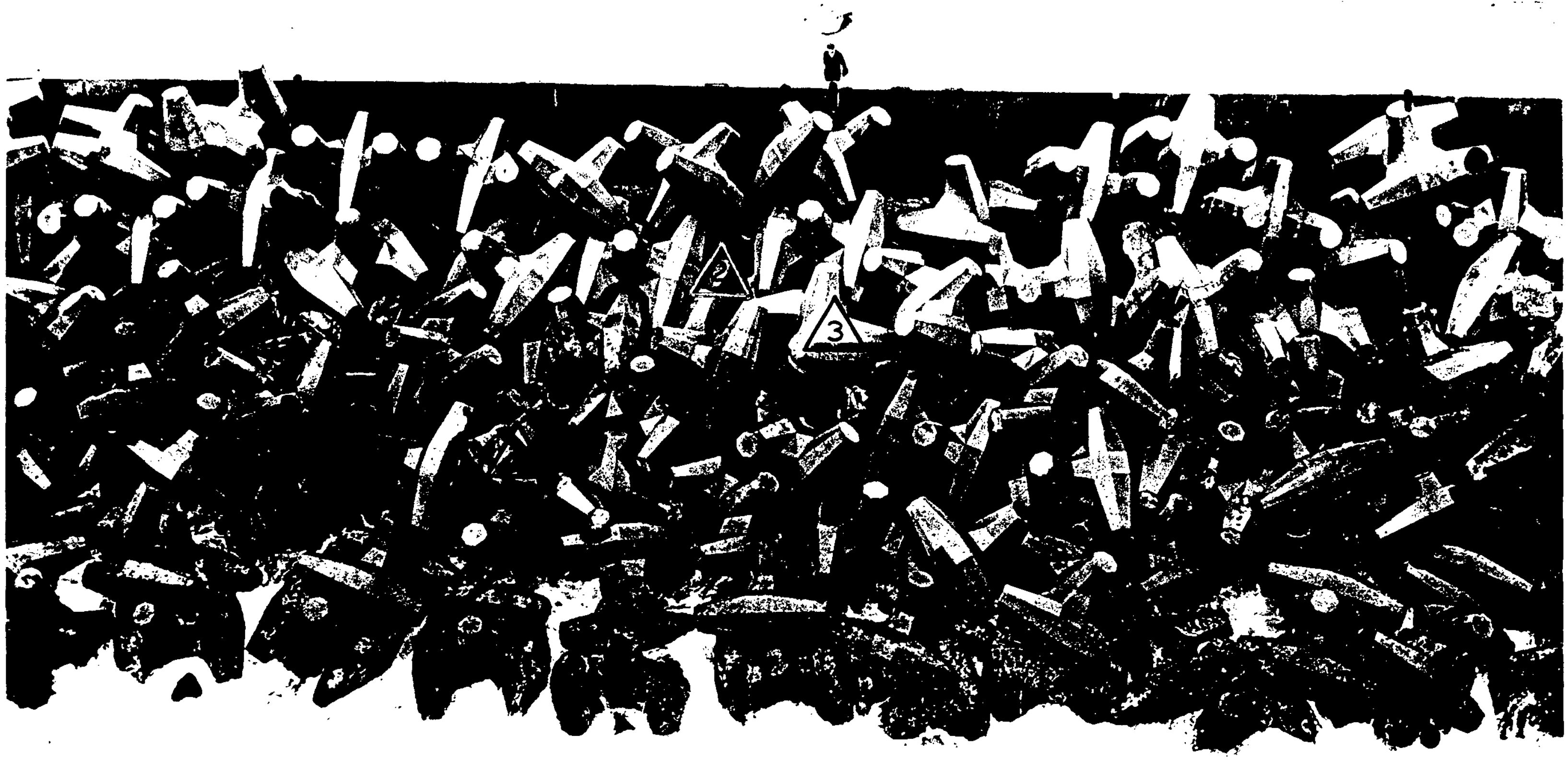
BASELINE PHOTOGRAPHIC SURVEY OCTOBER 1997
STATION 3

FIGURE 13



4

Move (■) : 0 Broken (▲) : 3 Lost (●) : 0

N = New, P = Pieces, A = <0,5m, B = 0,5m to 1,5m, C = >1,5m

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Move (■) : 0 Broken (▲) : 10 Lost (●) : 0

N = New, P = Pieces, A = <0,5m, B = 0,5m to 1,5m, C = >1,5m

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BASELINE PHOTOGRAPHIC SURVEY OCTOBER 1997
STATION 5

FIGURE 15

Move (■) : 0 Broken (▲) : 4 Lost (●) : 0

N = New, P = Pieces, A = <0,5m, B = 0,5m to 1,5m, C = >1,5m

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BASELINE PHOTOGRAPHIC SURVEY OCTOBER 1997
STATION 6

FIGURE 16

Move (■) : 0   Broken (▲) : 1   Lost (●) : 0

N = New, P = Pieces, A = <0,5m, B = 0,5m to 1,5m, C = >1,5m

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Move (■) : 0 Broken (▲) : 3 Lost (●) : 0

N = New, P = Pieces, A = <0,5m, B = 0,5m to 1,5m, C = >1,5m

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Move (■) : 0 Broken (▲) : 2 Lost (●) : 0

N = New, P = Pieces, A = <0,5m, B = 0,5m to 1,5m, C = >1,5m

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Move (■) : 0 Broken (▲) : 6 Lost (●) : 0

N = New, P = Pieces, A = <0,5m, B = 0,5m to 1,5m, C = >1,5m

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Move (■) : 0 Broken (▲) : 1 Lost (●) : 0

N = New, P = Pieces, A = <0,5m, B = 0,5m to 1,5m, C = >1,5m

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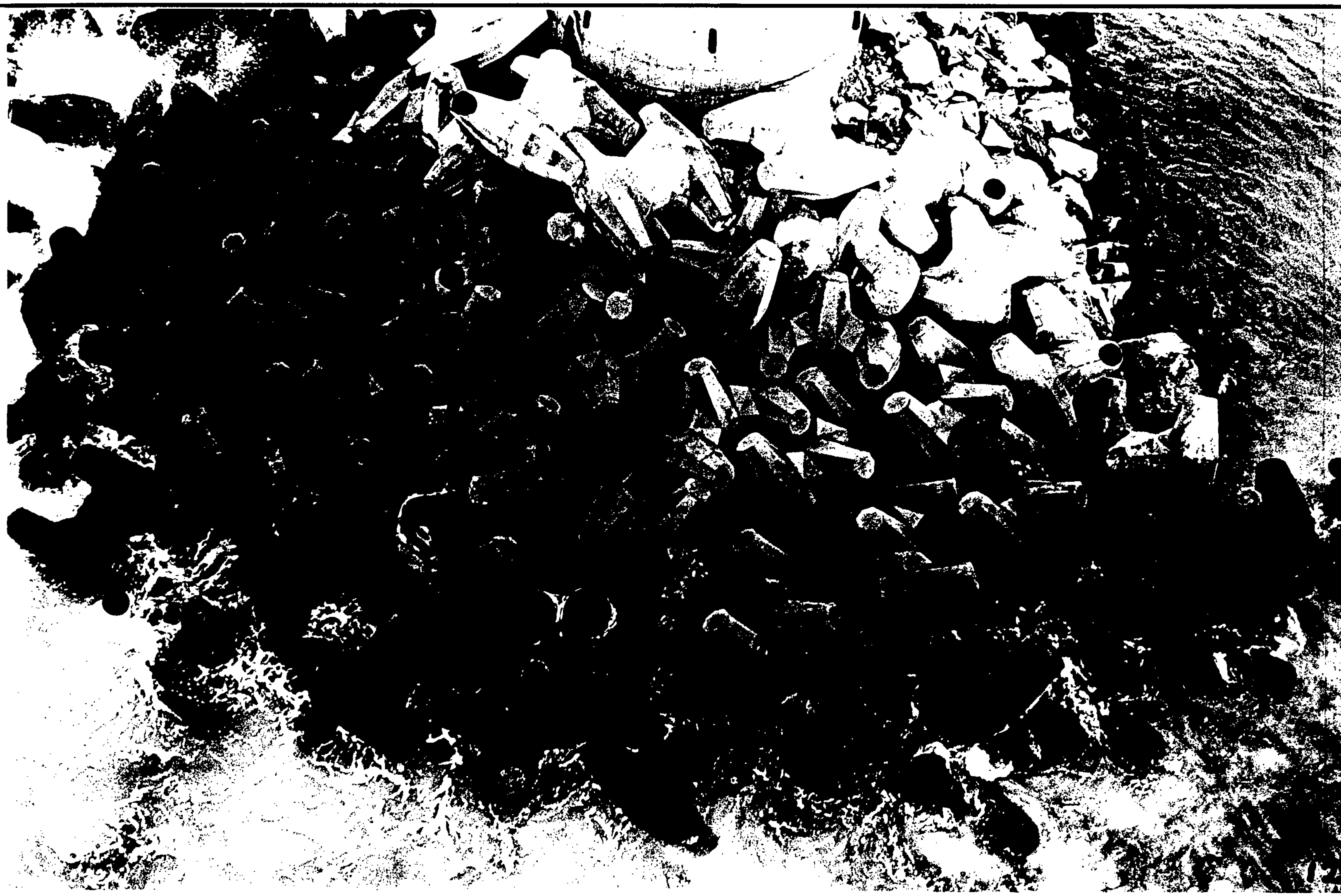
STATION 11

FIGURE 21



Move (■) : 0 Broken (▲) : 0 Lost (●) : 0

N = New, P = Pieces, A = <0,5m, B = 0,5m to 1,5m, C = >1,5m

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Move (■) : 0   Broken (▲) : 0   Lost (●) : 0

N = New, P = Pieces, A = <0,5m, B = 0,5m to 1,5m, C = >1,5m

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STATION 13

FIGURE 23

Move (■) : 0 Broken (▲) : 0 Lost (●) : 0

N = New, P = Pieces, A = <0,5m, B = 0,5m to 1,5m, C = >1,5m

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STATION 14

FIGURE 24

Move (■) : 0   Broken (▲) : 4   Lost (●) : 0

N = New, P = Pieces, A = <0,5m, B = 0,5m to 1,5m, C = >1,5m

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Move (■) : 0 Broken (▲) : 1 Lost (●) : 0
N = New, P = Pieces, A = <0,5m, B = 0,5m to 1,5m, C = >1,5m

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Move (■) : 0 Broken (▲) : 0 Lost (●) : 0
N = New, P = Pieces, A = <0,5m, B = 0,5m to 1,5m, C = >1,5m

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Move (■) : 0 Broken (▲) : 0 Lost (●) : 0

N = New, P = Pieces, A = <0,5m, B = 0,5m to 1,5m, C = >1,5m

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STATION 18

FIGURE 28

Move (■) : 0 Broken (▲) : 0 Lost (●) : 0
N = New, P = Pieces, A = <0,5m, B = 0,5m to 1,5m, C = >1,5m

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STATION 19

FIGURE 29

Move (■) : 0 Broken (▲) : 0 Lost (●) : 0

N = New, P = Pieces, A = <0,5m, B = 0,5m to 1,5m, C = >1,5m

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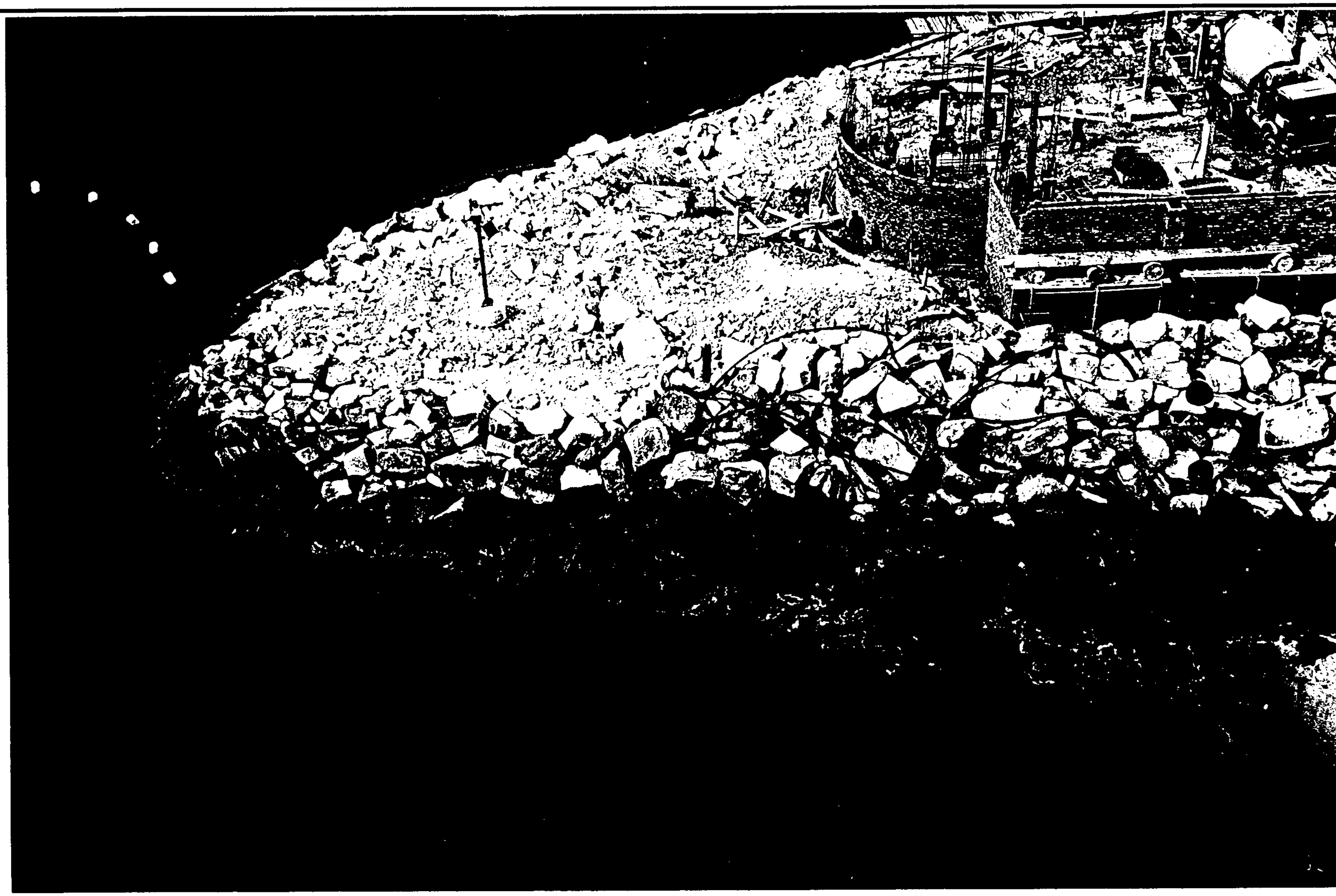

Move (■) : 0　　Broken (▲) : 0　　Lost (●) : 0

N = New, P = Pieces, A = <0,5m, B = 0,5m to 1,5m, C = >1,5m

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Move (■) : 0 Broken (▲) : 0 Lost (●) : 0 New (N) : 0

N = New, P = Pieces, A = <0,5m, B = 0,5m to 1,5m, C = >1,5m

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Move (■) : 0 Broken (▲) : 0 Lost (●) : 0 New (N) : 0

N = New, P = Pieces, A = <0,5m, B = 0,5m to 1,5m, C = >1,5m

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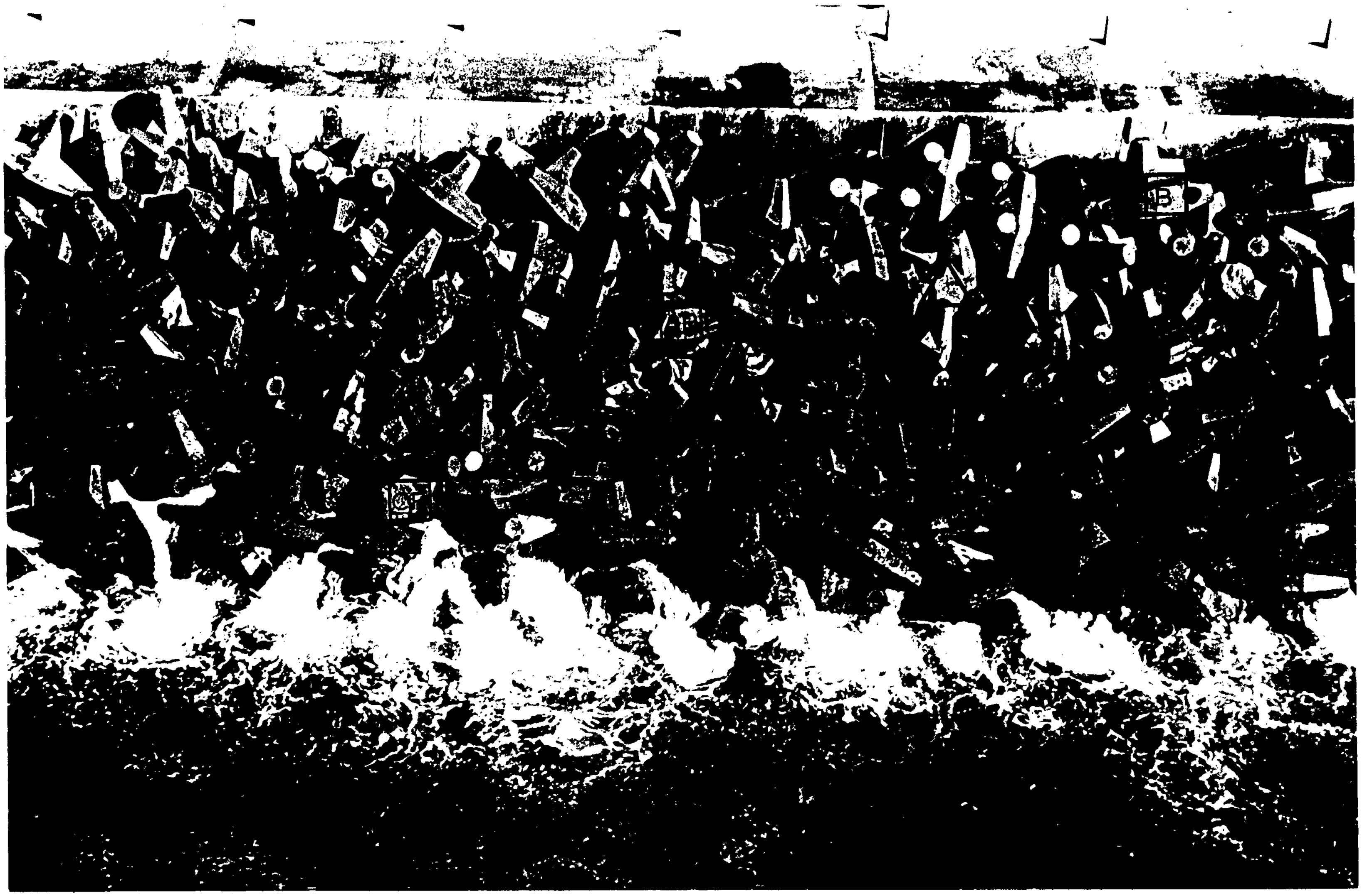

Move (■) : 3   Broken (▲) : 1   Lost (●) : 0   New (N) : 0

N = New, P = Pieces, A = <0,5m, B = 0,5m to 1,5m, C = >1,5m

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FOLLOW-UP PHOTOGRAPHIC SURVEY MAY 1998
STATION 4

FIGURE 34

Move (■) : 1   Broken (▲) : 0   Lost (●) : 0   New (N) : 3

N = New, P = Pieces, A = <0,5m, B = 0,5m to 1,5m, C = >1,5m

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STATION 5

FIGURE 35

Move (■) : 1 Broken (▲) : 0 Lost (●) : 0 New (N) : 0

N = New, P = Pieces, A = <0,5m, B = 0,5m to 1,5m, C = >1,5m

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STATION 6

FIGURE 36

Move (■) : 3 Broken (▲) : 1 Lost (●) : 0 New (N) : 0

N = New, P = Pieces, A = <0,5m, B = 0,5m to 1,5m, C = >1,5m

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Move (■) : 1 Broken (▲) : 0 Lost (●) : 0 New (N) : 0
N = New, P = Pieces, A = <0,5m, B = 0,5m to 1,5m, C = >1,5m

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STATION 8

FIGURE 38

Move (■) : 0   Broken (▲) : 0   Lost (●) : 0   New (N) : 0
N = New, P = Pieces, A = <0,5m, B = 0,5m to 1,5m, C = >1,5m

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STATION 9

FIGURE 39

Move (■) : 0 Broken (▲) : 0 Lost (●) : 0 New (N) : 0

N = New, P = Pieces, A = <0,5m, B = 0,5m to 1,5m, C = >1,5m

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FOLLOW-UP PHOTOGRAPHIC SURVEY MAY 1998
STATION 10

FIGURE 40

Move (■) : 0 Broken (▲) : 0 Lost (●) : 0 New (N) : 0

N = New, P = Pieces, A = <0,5m, B = 0,5m to 1,5m, C = >1,5m

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STATION 11

FIGURE 41